Consolidated points and issues for discussion on the Hypoxia Advisory Panel Subgroup 2 Teleconference – 10-16-06

Draft Outline to Guide Teleconference Discussion

2. Characterization of Nutrient Fate, Transport and Sources

Charge: *Nutrient loads, concentrations, speciation, seasonality and biogeochemical recycling processes have been suggested as important causal factors in the development and persistence of hypoxia in the Gulf. The Integrated Assessment (CERN 2000) presented information on the geographic locations of nutrient loads to the Gulf and the human and natural activities that contribute nutrient loadings.*

Based on your understanding of the current science:

- **Are there summaries, conclusions, and recommendations presented in the 2000 Integrated Assessment that you believe are no longer accurate or valid?**
- **What new findings are most relevant to this review and how do they alter our understanding of nutrient sources, fate, and transport and our ability to model the system(s)?**
- **What are the strengths and limitations of those new findings and models that will determine the level of confidence in our conclusions and recommendations, and will help to identify major gaps in our understanding?**

A. Given the available literature and information (especially since 2000), data and models on the loads, fate and transport and effects of nutrients, evaluate the importance of various processes in nutrient delivery and effects. These may include:

*Topic 2Ai: The pertinent **temporal** (annual and seasonal) characteristics of nutrient **loads/fluxes** throughout the Mississippi river basin and, ultimately, to the Gulf of Mexico. (David & Howarth)*

David: Estimate Temporal Loads/Fluxes Thoughout Basin

Howarth: Comparison of Landscape Scale Models for Estimating N/P Fluxes and Sources

*Topic 2Aii: The ability to determine an accurate **mass balance** of the nutrient loads throughout the basin. (David)*

David: Estimate Nutrient Mass Balance Throughout Basin

*Topic 2Aiii: Nutrient transport processes (**fate/transport, sources/sinks, transformation**, etc.) through the basin, the deltaic zone, and into the Gulf. (Meyer, Howarth, Blumberg, Lowrance, Crumpton, Boynton)*

Meyer: Nutrient Transport and Transformation in Small Streams and Rivers

I. Identified research needs relevant to this topic from Integrated Assessment reports

A. Goolsby et al. (1999)

1. Studies in small watersheds to identify dynamics and timing of N transport from croplands to streams, to better define the extent and density of tile and other agricultural drainage, and to better understand the impact of these drainage practices on nutrient flux in large rivers. (7.2)
2. Reduce uncertainty about the role of instream processes such as denitrification (particularly in small streams) in removing N and identify ways to enhance these processes to reduce nitrate leaching to streams and ground water. (7.3)

B. Mitch et al. (1999)

1. Better understanding of N behavior during floods, particularly ecotechnological methods for nitrate control, such as riparian zones and other wetlands.

II. Recent research

A. Models suggest that in-stream nitrogen removal is substantial across river networks.

1. Estimates of in-stream nitrogen removal in regional drainages in the Mississippi River basin range from 10-60% (SPARROW model, Alexander et al. 2000) and 18 to 50% (Donner et al. 2004) of nitrogen inputs to surface waters.
2. In sixteen river networks in the Northeastern United States, Riv-N model predicted that 37 to 76% of nitrogen inputs were removed within streams (Seitzinger et al. 2002), and the SPARROW model predicted that 7 to 54% of nitrogen inputs were removed (Alexander et al. 2002).
3. For the Rhine and Elbe river basins, another model (PolFlow) predicted that 14 to 45% of N input to surface water was removed in the river network (De Wit 2001).
4. In Seine watershed, N retention retention in rivers is 24-32 x 10^3 tons/yr, whereas retention is 70-110 x 10^3 tons/yr in riparian zones. From

25-55% of N coming from below rooting zone or aquifer is retained before entering the river. There is a direct relationship between % watershed drained via tile drains and riparian transfer coefficient (i.e. % N transported through riparian zone increases with increasing tile drainage) (Billen 1999).

B. The role of small streams

1. Network nitrogen removal increased with total stream length (r^2 = 0.84), and increasing drainage density in a watershed (i.e., increasing map scale of hydrography from 1:500,000 to 1:100,000 increased the proportion of nitrogen removed by 8 to 31 percentage points) (Seitzinger et al. 2002).
2. Small streams remove a higher proportion of their incoming nitrogen per unit of water travel time (Alexander et al. 2000), per stream reach (Seitzinger et al. 2002), and per unit length (Wollheim et al. 2006, Helton 2006). Although larger stream reaches remove smaller fractions of their nitrogen, they remove larger masses of nitrogen because more nitrogen passes through them (Seitzinger et al. 2002, Wollheim et al. 2006, Helton 2006).
3. In NC, 50% of NO_3-N removal occurred in streams with catchment areas less than 20 km^2, and in KS 50% of NO_3-N removal occurred in stream segments with catchment areas less than 10 km^2 (models in Helton 2006; MS Thesis).
4. SPARROW modeling in the Northeast has shown that N removal in headwaters reduces N load in headwaters by 12%, and in 6th order streams by 5-6%. This means that 40% (5/12) of the headwater load reduction is still observable in 6th order streams (Alexander et al. 2007).

C. Studies in small watersheds

1. In small (2nd order streams) Minnesota watersheds with sandy soils, extensive wetlands, and intermittently grazed pasture, nitrate removal from ridge through the riparian zone is a function of organic C availability; removal in hyporheic zone and streams is a function of temperature (i.e., there is adequate stored organic C) (Triska et al. 2007).
2. N loads to headwaters account for 45% of entire load delivered to the entire river network (1:100,000 scale) in streams in the Northeast. N loads from headwaters account for decreasing amounts of N in higher order rivers and streams: from 65% in 2nd order to 40% in sixth order (Alexander et al. 2007).

D. Model comparisons

1. In NE watersheds, 6 different models were able to predict measured nitrogen export to within 50% in majority of watersheds ranging in size from 475 to 70,000km^2. Models overpredicted export where there was

little agriculture in the basin and where runoff was low; models underpredicted export where there was a lot of agriculture and where runoff was high. Models (SPARROW and Howarth) with greatest detail on N sources, attenuation, and water flow paths were the best predictors (Alexander et al. 2002).

III. Conclusions

A. Models based on a hydrography layer that does not adequately capture actual drainage density will underestimate the capacity for nutrient removal by in-stream processes.

B. Strategies for reducing N and P loading should include enhancing nutrient removal capacity of small streams in proximity to N and P sources.

C. Enhancing nitrogen removal capacity in riparian zones requires an adequate supply of bio-available organic carbon.

Howarth: Denitrification and P Sorption/Desorption in Larger Rivers and Gulf

Blumberg: Physical Aspects of Transport, Including in Gulf

Lowrance: Effectiveness of Wetlands, Agricultural Practices, and Understanding the Timing, Application Rates, and Forms of Current-Use Fertilizers

Crumpton: Effectiveness of Agricultural Management Practices

Boynton: Nutrient Fate in Wetlands and Estuaries

B. Given the available literature and information (especially since 2000) on nutrient sources and delivery within and from the basin, evaluate capabilities to:

*Topic 2Bi: **Predict nutrient delivery to the Gulf**, using currently available scientific tools and models. (Mankin & Reckhow)*

Mankin: Transport Processes Throughout the Basin – Source to Stream

Reckhow: Focus on the Current Ability to Model Nutrient Delivery

Topic 2Bii: ***Route nutrients*** *from their various sources and account for the* ***transport processes*** *throughout the basin and deltaic zone, using currently available scientific tools and models. (Blumberg, Mankin & Reckhow)*

Blumberg: Physical Aspects of Transport Processes

Mankin: Account for Transport Processes Throughout the Basin

Reckhow: Focus on the Current Ability to Model Nutrient Routing

Literature Cited

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